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PHYS - 231

Ch. 5 # 36, 39, 42, 46
(49, 50, or 51)

Problem 36

$r = 7.2\times10^{-15}$ m

$\Delta x = 2r$

$\Delta p \geq \frac{\hbar}{2\Delta x}$ $\quad \hbar = \frac{h}{2\pi}$

$$K_{min} = \frac{(\Delta p)^2}{2m} = \frac{\hbar^2}{4\Delta x^2 \cdot 2m} = \frac{\hbar^2}{8\Delta x^2 \cdot m} = \frac{(\hbar c)^2}{8\Delta x^2 m}$$

$$\frac{(eV^2 \cdot s^2)}{m^2 \cdot (eV/c^2)} \cdot \frac{c^2}{c^2} = eV$$

$\Delta x = 1.44\times10^{-14}$ m

$m = 938.27$ MeV/c^2

$\hbar c = 197.33$ eV·nm

$$K_{min} = \frac{(197.33\times10^{-9}\ eVm)^2}{8(1.44\times10^{-14} m)^2(938.27\times10^6 eV)} = 25{,}017.5\ eV$$

$$\boxed{K_{min} = 2.5\times10^4\ eV}$$

Problem 39

a.) Show that $\Delta L \Delta\theta \geq \hbar/2$ $\qquad \Delta p \Delta x \geq \frac{\hbar}{2}$

$L = mvr$

$\Delta L = mv\Delta x$

$\Delta x = \frac{\Delta L}{mv}$

$$\Delta\theta = \frac{\Delta P}{P} = \frac{\Delta P}{mv} = \frac{\hbar}{2mv\Delta x} = \frac{\hbar\ mv}{2m v \Delta L} = \frac{\hbar}{2\Delta L}$$

$$\Delta\theta = \frac{\hbar}{2\Delta L} \quad : \quad \boxed{\Delta L \Delta\theta \geq \frac{\hbar}{2}\ ✓}$$

b.) $\Delta\theta = 0$

if $\Delta\theta = 0$ then, ΔL must be $\frac{\hbar}{4\pi}$

$$\boxed{\Delta L = \frac{\hbar}{4\pi}}$$

Problem 42

$m = 3.0 \times 10^{-15}\ kg$

$\Delta x = 1.0 \times 10^{-6}\ m$

$\hbar = \frac{h}{2\pi}$

$$\Delta p \Delta x \geq \frac{\hbar}{2} \qquad \Delta p = m\Delta v$$

$$m\Delta v \Delta x \geq \frac{\hbar}{2}$$

$$\Delta v \geq \frac{\hbar}{2m\Delta x} \geq \frac{(6.626 \times 10^{-34}\ J \cdot s)/2\pi}{2(3.0 \times 10^{-15}\ kg)(1.0 \times 10^{-6}\ m)} \geq 1.757 \times 10^{-14}\ m/s$$

$$\boxed{\Delta v \geq 1.76 \times 10^{-14}\ m/s}$$

Problem 46

$E = 5.5 \times 10^{6}\ eV$

$h = 4.14 \times 10^{-15}\ eV \cdot s$

$m = 3,727.38 \times 10^{6}\ eV/c^2$

$d \approx 1.6 \times 10^{-14}\ m$

$$\lambda = \frac{hc}{\sqrt{2mE}} = \frac{(4.14 \times 10^{-15}\ eV \cdot s)(3.0 \times 10^{8}\ m/s)}{\sqrt{2(3,727.38 \times 10^{6}\ eV/c^2)(5.5 \times 10^{6}\ eV)}} = 6.13 \times 10^{-15}\ m$$

$\lambda = 6.13 \times 10^{-15}\ m$, since $\lambda < d$, the particle cannot exist inside the ^{241}Am nucleus.

Problem 49

A radioactive substance is placed into a box with a cat. A geigercounter is also put inside the box where the radioactive material has a 50% chance of decaying. If the substance decays, a poisonous gas will be released and the cat will die. If not, it will live.

Schröedingers cat is the question of how do we know wheter or not the cat is alive from outside the box. In short, there is no way to know until the box is opened.

There is some belief that there might be a superposition where the cat is both dead and alive. This physically does not make much sense and can't really be experimentally verified. With that being said, the cat can either be dead or alive depending on the experiments outcome.